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PROSPECTING IN NEW BRUNSWICK (SESSION III)

82-23

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Department of Natural Resources
Province of New Brunswick

Hon. Gerald S. Merrithew

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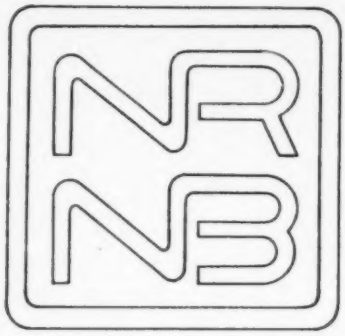
Expansion

Hon. Herb Gray, Minister

PROSPECTING IN NEW BRUNSWICK
(SESSION III)



Mineral Resources Division
Department of Natural Resources
New Brunswick

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Mineral Resources Division
Department of Natural Resources
P. O. Box 6000, Fredericton, N.B.
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Report No.: Open File Report 82-23

Author: W. E. Hale (University of New Brunswick, Geology Department)

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NOTES

on

PROSPECTING IN NEW BRUNSWICK

by

W.E. Hale

SESSION THREE

Topographic Maps and Surface Geological Processes

January, 1981

Revised January, 1982

Notes on
PROSPECTING IN NEW BRUNSWICK
W.E. Hale

SESSION THREE
Topographic Maps and Surface Geological Processes

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FILMS (Appropriate if time available)
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MAPS (to be displayed and discussed by the instructor)
1. Glacial Map, Canada
2. Geological Map, N.B. 1:500,000
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4. Topographic Map, Southern N.B. 1:250,000
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6. Pleistocene Geology (Lee or Gadd)

OTHER ITEMS REQUIRED
1. Pocket Stereoscopes
2. Geometry Sets (for Topo Exercise)

NOTES ON
PROSPECTING IN NEW BRUNSWICK
W.E. Hale

SESSION THREE
(of six)

TOPOGRAPHIC MAPS AND SURFACE GEOLOGICAL PROCESSES

GENERAL INTRODUCTION

This session (Three) deals with the geological processes that occur (and can be observed) on the earth's surface. It also introduces the trainee to the topographic or surface map. The topographic map may be used as a means of interpreting the surface processes that have been active in an area. This, in turn, provides the prospector with useful guidance in his search of that surface for ore. (Those trainees familiar with topographic maps, their symbols, scales, etc., should move on directly to the study of the surface processes themselves and their influence on ore localization).

A necessarily abbreviated treatment of topographic maps and surface processes will be presented in these notes. The trainee should obtain additional topographic maps (from the Provincial Department of Natural Resources offices) for areas of his/her particular interest and practise 'reading' them. Indexes showing available topographic maps and aerial photographs, on various scales, may be purchased or consulted (at no cost) at the DNR, Fredericton, or its branch offices in Bathurst and Sussex.

The prospector will devote a major portion of his/her effort, both in planning and actual field work, to the study of surface processes. Identifying surface materials, their forms,

interpreting their history and relating this to possible ore localization will require study and practice over and above the simple exercises of this session.

The topics of this session are presented in your lab manuals (Hamblin and Howard, 1980) in Chapters 7 to 15 inclusive. This manual was prepared and published in the U.S. and thus most of the examples are from American locations. Geological processes, however, are not nationally restricted and, therefore, understanding the examples used in the manual will provide a basis for understanding surface products and processes in N.B. Under the several subdivisions treated in this session some N.B. examples will be cited and in some cases used.

From the references recommended for this program, the trainee will find more detailed reviews of surface geological processes in Reference 10 (Physical Geology, Plummer and McGeary, 1979), Chapters 5, 6, 9, 10, 11, 12, 13 and 14 and in Reference 6 (Principles of Physical Geology, 1978), Chapters 3, 6, 7, 12, 14, 15, 16, 17, 18, 19, 20, 22, 23, and 24. Some other texts (not in your list) deal with surface processes as a unit and in this sense may be more helpful, e.g. "The Changing Earth" (G.C. Milligan, 1977, McGraw-Hill Ryerson Ltd., Toronto, Part III) and "Earth" (Press & Siever, 1978, W.H. Freeman & Co., San Francisco).

3.2.0 TOPOGRAPHIC MAPS

3.2.1 Introduction

The prospector's interest is 'in the field'. Useful activities including planning, self-training, collection and

review of data, preparation of property or claim descriptions, etc., can be done indoors, especially in areas such as N.B., where winter conditions generally make prospecting, in the traditional sense, impossible for close to six months each year. However, these indoor activities should be considered as supporting operations for the main effort in the field.

Field work should be carefully planned, efficiently carried out and reliably recorded. This is equally true whether the prospector works for a company or individually. Many prospectors detract from interest in their work or property by having only general ideas about the location of ground they've covered, samples they've collected and results they've obtained. A 'basemap' must be used for location control. The most common base is a topographic map. Aerial photos may be considered as a type of topographic map.

A topographic map is a representation (or 'picture') of the surface of the earth in two dimensions and on a scale that relates distance on the ground to a corresponding distance on the map. There are many types of topographic maps, depending on the different kinds of information being displayed on them.

Contour lines are a means of representing the third dimension (height) on topographic maps and the prospector can make good use of contours in his field work. For some areas and on some scales 'contours' are not provided; airphotos are commonly not contoured.

The trainee should now proceed to the lab manual, beginning with Ch. 7, p. 59.

3.2.2 Aerial Photographs and Topographic Maps

Following the instructions given on p. 197 (of your manuals), and removing the photo-pages from the manuals, practice with the pocket stereoscope using air photos to observe parts of the earth's surface in three dimensions. This simple skill will prove to be extremely useful in locating in the field. The examples of different tones on the black and white photos (Fig. 14, p. 61) will serve as an introduction to air photo interpretation.

3.2.3 Contour Lines

Contour lines are explained on p. 62 of your lab manuals and an exercise in constructing a contour map is presented on p. 64. Do this exercise in your own time.

A comparison of a stereo pair of aerial photographs and a contoured, topographic map of the same area is provided on pages 66 and 67 of your manuals. You may view the aerial photographs with the stereoscope but the questions that follow may be answered in your own time, following the session. They may be answered from a study of the contoured map (p. 67) alone.

3.2.4 Topographic Map Exercise

An exercise (on N.T.S. Sheet, 1:50,000, Fredericton, N.B.) with explanatory notes used in introductory geology courses at UNB follows. For instructions on how to draw a topographic profile, refer to your lab manuals (p. 68). Read the notes below and do the exercise.

UNB Geology Department Lab Exercise

Scale

Distances on a map are proportional to distances on the earth's surface which the map represents and the ratio of the two determines the scale of the map. A large scale map covers a smaller area but shows greater detail than a small scale map. The scale is often expressed as a ratio, called the representative fraction, such as 1:63,360, meaning that one inch (or any other unit) on the map is equivalent to 63,360 inches (or other corresponding unit) on the ground. This scale can also be expressed as one inch equals one mile (63,360 inches). A common ratio used on Canadian maps is 1:50,000. The ratio can be converted directly into yards, feet, metres or into any unit of measurement. Scales can also be expressed in words (one inch equals one mile) or by a linear scale on the map. Since the earth's surface is not a plane, but part of a spheriod, drawing it on a flat surface causes distortion of shape and size in all but small areas and the projection is a geometrical arrangement to keep distortion at a minimum.

Latitude and Longitude

A worldwide coordinate system is based on Latitude and Longitude. Parallels of Latitude are indicated by circles drawn around the earth parallel to the equator. Those north of the equator are the northern latitudes', in the northern hemisphere, and those to the south are the southern latitudes. The equator is designated zero latitude. From the equator to each pole there are 90 degrees of latitude. The angle of latitude may be measured from the equator to the centre of the earth and from there to the point on the surface of the earth for which the latitude is desired. Latitude measurements involve radial measurements and are expressed in degrees, minutes and seconds.

Meridians of Longitude are great circles drawn around the earth through the poles. The reference meridian or Prime Meridian of zero longitude is drawn through an observatory at Greenwich, near London, England. The Prime Meridian divides the world into two halves, the eastern and the western hemispheres. Angles of Longitude are measured from 0° to 180°, east and west of the Greenwich meridian.

On most maps the eastern and western boundaries of the maps are meridians. The longitude is marked at the top and bottom of the map in degress (°), and seconds ("). The top and bottom boundaries are lines of latitude.

Studies of topographic maps are divided into two parts:

1. Actual map reading for the purpose of determining position, relief, slopes, gradiant, water courses, etc.

2. An interpretation of the surface forms visualized from above in terms of the underlying rock materials and the nature and sequence of geological processes, especially those involving surface erosion and deposition, to which the area has been subjected.

The map reading must be mastered completely before the interpretations can be attempted.

Features on most published topographic maps may be divided into 3 groups:

1. Relief - generally shown by contour lines
2. Water - generally shown in blue
3. Cultural - man-made structures

It is particularly important to be able to visualize relief features as they yield a great deal of geological information. Although relief is generally indicated by contour lines, various techniques of hachuring, shading and colouring are occasionally used, but generally lack the quantitative precision of contour lines. Spot heights add additional information.

Contours

Contours are lines on a topographic map drawn through points of equal elevation. Mean sea level is commonly taken as the datum or reference plane with zero elevation. The contour interval is the difference in elevation (vertical distance) between adjacent contours. The horizontal distance between contour lines is known as the contour spacing. The slope of the ground is steep where contours are close together and gentle where they are far apart. Superimposed contours indicate a vertical cliff. Depressions are indicated by hachured contour lines. The following are normal topographic relations which are used as "rules of thumb" when constructing and observing topographic maps:

1. Contour lines 'V' or 'U' upstream.
2. Contour lines never cross one another.
3. The closer the contours, the steeper the slope.

All maps must show: a scale; a north line: a title: a legend or explanation or symbols, and source.

Relief features cannot be properly appreciated without knowing both the scale and the contour interval for each map studied.

For the Fredericton Sheet, that will be supplied by the instructor, answer the following:

1. What is the scale? Contour interval? Longitude and latitude of the U.N.B. campus? Magnetic declination at UNB at the present time?

2. Note the list of conventional signs on the east side of the map. Find one example of each. How "up to date" are the data?

3. What is the direction (bearing) of the York Sunbury County line?

4. What is the highest point on the map? Lowest?

5. What is the average gradient in ft./mi. of Campbell Creek (N.E. 9th*) from where it enters the map area at the N.E. corner to where it enters the Nashwaak R.?

6. Draw a topographic profile from New Market to Yoho. (A xerox copy of this portion of the Fredericton Sheet is included here on next page so that this part of the exercise can be completed at home). Fig. 1, p. 8.

3.3.0 SURFACE PROCESSES

3.3.1 Introduction

Although modern mineral exploration includes methods such as geophysics, that identify shallow sub-surface conditions, prospecting is still primarily a surface operation. Even where sub-surface methods are employed, a knowledge of surface materials and processes is essential to their interpretation.

Some ores are formed entirely by surface processes, e.g. placer gold. Mineral fuel deposits such as coal were formed on the surface, buried and then up-lifted to their present positions. Many other deposits are hidden from direct observation by a relatively thin cover of surface material. Most ore minerals that formed below the surface when uplifted, react with surface agents: water, air, vegetation, etc. and change as a result, indeed, the geochemical method of prospecting is dependent on this interaction.

*N.E. 9th refers to a convention commonly used for dividing a map into 9, more or less, equal parts, 3 across and 3 up and down, designated N, NE, E, SE, S, SW, W, NW, and C (central).

Scale 1 50,000

FIGURE 1. PART OF FREDERICTON SHEET

In the summary that follows, the major surface geological processes will be described and, where appropriate, lab. exercises from the manual will be recommended for further familiarization with this important topic. New Brunswick examples will be cited where possible. Ore deposits that may form in each surface process will be noted with particular reference to those that are known in New Brunswick.

Reference should be made again to the Rock Cycle and that portion of it beginning with 'weathering' and extending to 'sediments', Figure 2, p. 11. This is the surface portion of the cycle and is known as the 'exogenic (sub-) cycle' (from 'exo-' meaning outside and 'genic', referring to origin, in other words, processes that originate on the outside or surface of the earth. The forces required to drive the 'engine' of change represented by the rock cycle are primarily: heat from the interior of the earth, the sun's heat, and gravity. On the earth's surface the sun and gravity combine to 'drive' the surface processes.

3.3.2 Volcanism

a. General Information

It may be argued that volcanism, or the process from which volcanic rocks are formed, is not wholly a surface process since the mechanism begins below the surface. However, volcanoes demonstrate the link between surface and sub-surface processes. Some active or recent volcanoes are also locally dramatic surface geological features. Publicity about volcanoes in populated areas, e.g., Mt. St. Helens (Washington State, U.S.A.) might give

the impression that volcanoes are rare in both time and space. Such an impression would be understandable in New Brunswick and indeed most of the world where there are no active volcanoes within recorded history. On the other hand, there are well-defined parts or zones of the earth's crust where people live within sight of continually or intermittently erupting volcanoes.

Volcanoes and their products are well described in Reference 6 (Holmes, 1978, Principles of Physical Geology), Chapter 12, p. 188, and in Reference 10 (Plummer and McGeary, 1979, Physical Geology) Chapter 3, p. 40.

A detailed discussion of the types of volcanoes and the variety of deposits that are ejected from them onto the earth's surface is beyond the scope of this program. (Chapter 3 of your lab manuals deals with igneous rocks in general. Volcanic rocks are part of this major group of rocks and their specific textures and compositons are described and illustrated).

b. New Brunswick

The distribution of active volcanoes is illustrated in Figure 3, p. 14. It will be apparent that active volcanoes are associated with 'belts' of very young (geologically speaking) mountains. It will also be evident that no such young mountain belts or active volcanoes are recorded for eastern North America. This accounts for the lack of experience by New Brunswickers with volcanoes. However, it should be understood that the earth's crust and surface are in a state of constant change (even if this change is slow by human standards of time).

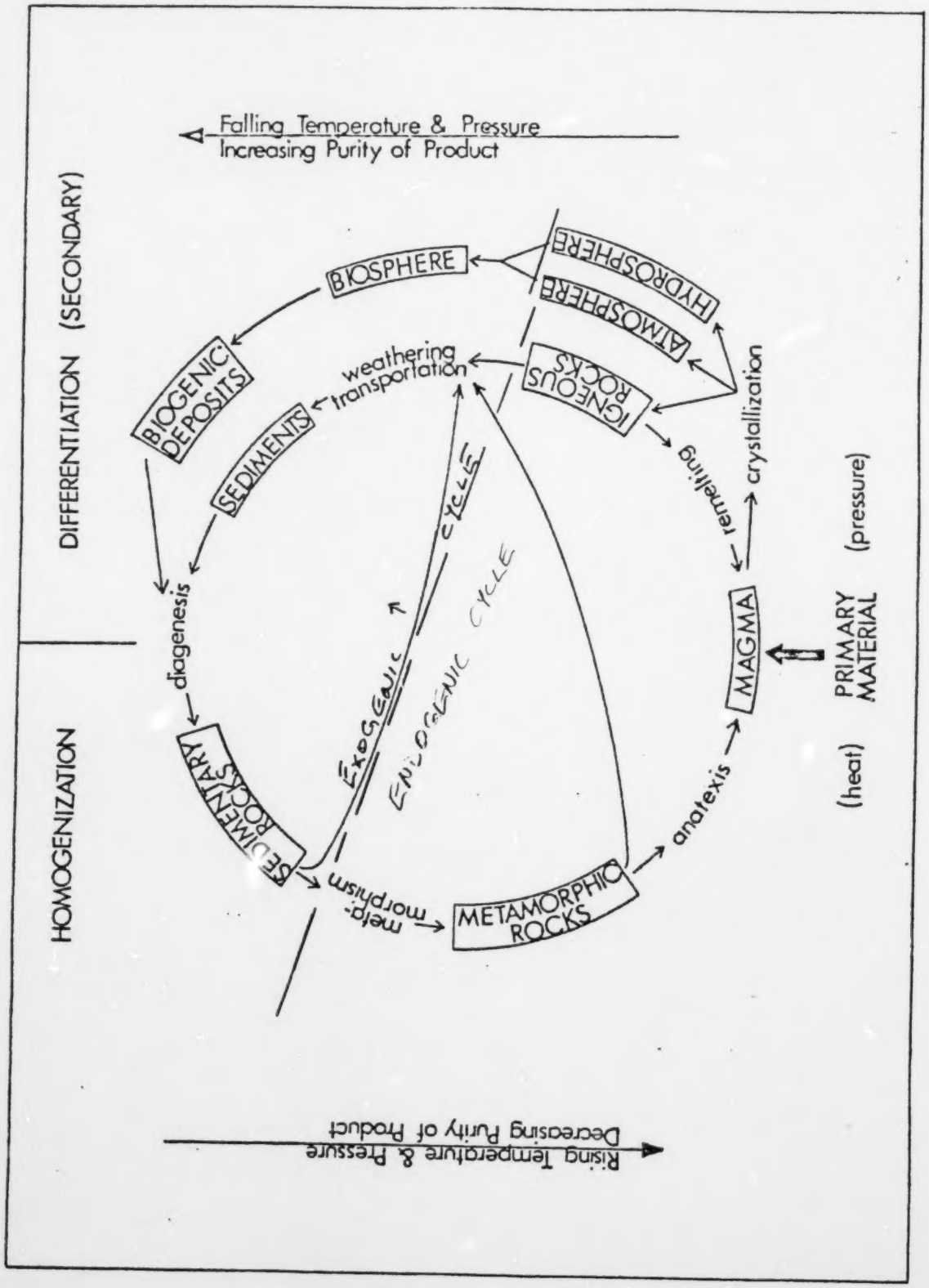

FIGURE 2. EXOGENIC CYCLE (of Rock Cycle)

(After Mason, 1958)

At least twice in the geological past, N.B. and the eastern part of North America experienced the complex process of mountain building and volcanism rivalling that now characteristic of the majestic and 'active' mountain ranges of western North and South America. During these past periods of volcanism, N.B. was dotted with active volcanoes that poured out lavas and volcanic ash in great quantities. Much of these earlier volcanic deposits have been preserved.

Volcanic rocks in New Brunswick are mostly old and deformed. They, therefore, do not resemble the volcanic material described in your manuals under the heading 'Volcanic Land Forms' (Chapter 12). An exception would be the comparatively young (about 200,000,000 years old) basalt on Grand Manan Island and in places along the Bay of Fundy shore, particularly the south shore of the Bay, from Digby to Minas Basin in Nova Scotia. The occurrences of volcanic rocks in New Brunswick is shown on the geological map of the province (a copy of which your instructor will display).

c. Volcanic Rocks and Ores

The geological map of the northeastern part of the province depicts areas of older volcanic rocks with which the Bathurst-Newcastle Pb-Zn ores are associated. The complex tin-tungsten-molybdenum mineralization at Mt. Pleasant in Chartlotte County, is believed to be associated with volcanic rocks formed in a manner illustrated in Fig. 4. (These areas will be pointed out by the instructor. A study by the trainee of the maps provided with this program will indicate other

occurrences of ore minerals associated with volcanic rocks in N.B.).

3.3.3 Weathering and Soils

a. General Information

All rocks weather in time. Even the most permanent-appearing rocks will eventually succumb to the action of: sunshine, rain, wind, ice, gravity, and other agents. Weathering is a variable and complex, generally slow, process. A visit to a cemetery and an examination of the inscriptions on the monuments will demonstrate two things about rocks: a) they do weather (within a relatively short time geologically), and b) different rocks weather at different rates. Monuments made from limestone (readily and easily available locally to early settlers) have their inscriptions 'blurred' relative to those made of granite at or near the same time.

In general, weathering is a process whereby hard, solid rocks are changed into soft, unconsolidated material easily transported by running water, wind, moving ice, etc. This process begins whenever and wherever rock is exposed at the surface and continues, essentially without interruption, until all exposed rock is removed and deposited eventually in the ocean.

Further general information on soils and their formation may be found in References 6 and 10. A classification of soil types will be found in Reference 6 (Holmes, 1978, Principles of Physical Geology, p. 259).

DISTRIBUTION OF ACTIVE VOLCANOES

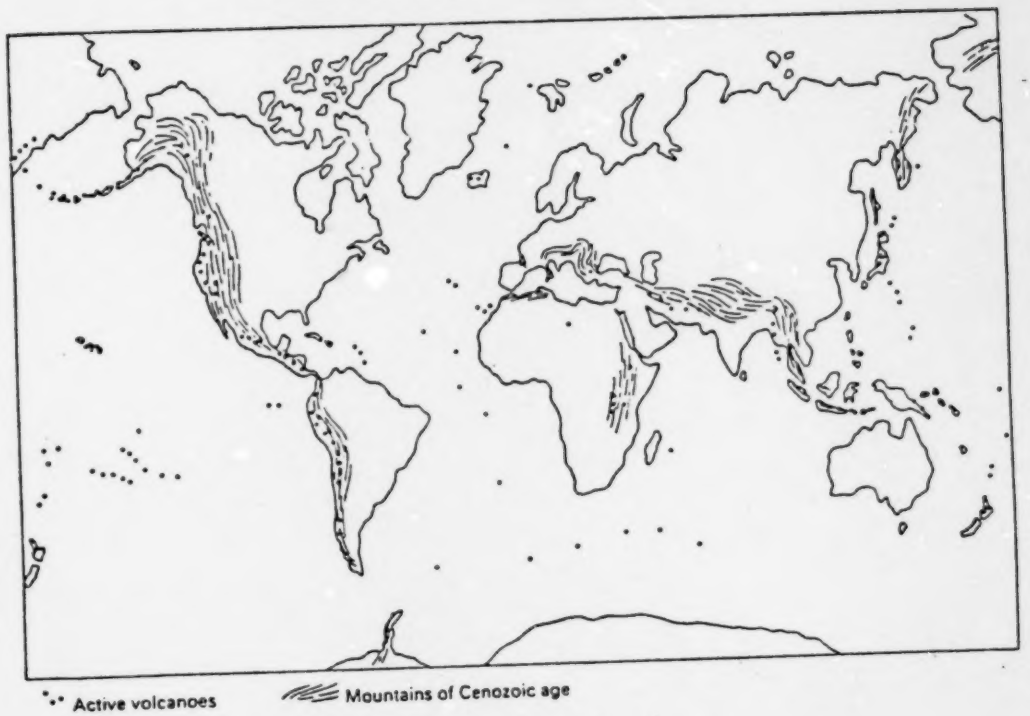

FIGURE 3 - World Distribution of Active Volcanoes
Source: Gilluly, Waters & Woodford, 1975, Principles of Geology, 4th Ed., W. H. Freeman & Co., San Francisco.

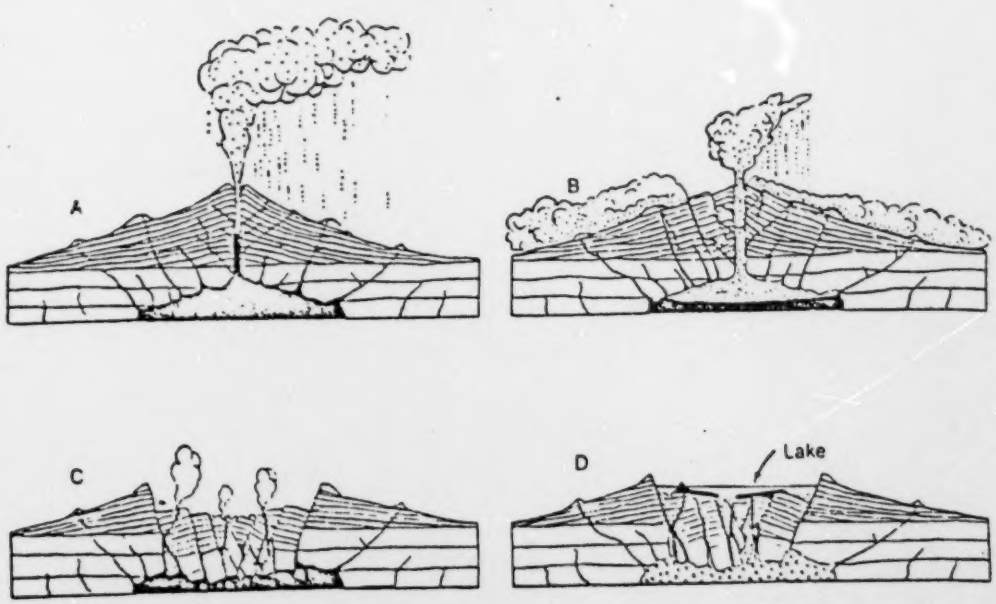

FIGURE 4. - Evolution of a volcanic cauldera
Source: as in Figure 3.

b. Canada and New Brunswick

Weathering, or the action of surface 'agents' on rock, is influenced by a variety of factors: climate, topography, characteristics of the rock, time, vegetation, man, etc. The weathering of rocks in the Arctic, or in high mountains, proceeds at a different rate and produces a different product from that which occurs in relatively flat areas in the humid tropics. Weathering in N.B. is somewhere in between these two extremes. It is important to realize, however, that topography and climate change over geologic time and N.B. has had high mountains and also tropical climates at times in the geological past.

The end product of weathering (before transportation) is soil (Fig. 5, p. 17) which, under undisturbed conditions and long periods of time, would reflect the climate and original rock that have interacted to produce it. However, in N.B. we have a further complication in relatively recent geological time (10,000-20,000 years ago). Residual soil is that which remains in place, above the rock from which it was derived, for 1000's of years. In much of Canada, including to some extent N.B., glaciers, acting like giant bulldozers, have scoured and pushed off this earlier residual soil to new locations and left in its place, when the glacier melted, smoothly polished rock covered with some of the debris that was carried in the ice. This debris deposited by the ice is transported soil and covers much of N.B. (Fig. 6, p. 17).

The influence of glaciation on the distribution and type of soils in Canada is treated in Reference 4 (Douglas, 1970, Geology and Economic Minerals of Canada). Of particular interest

occurrences of ore minerals associated with volcanic rocks in N.B.).

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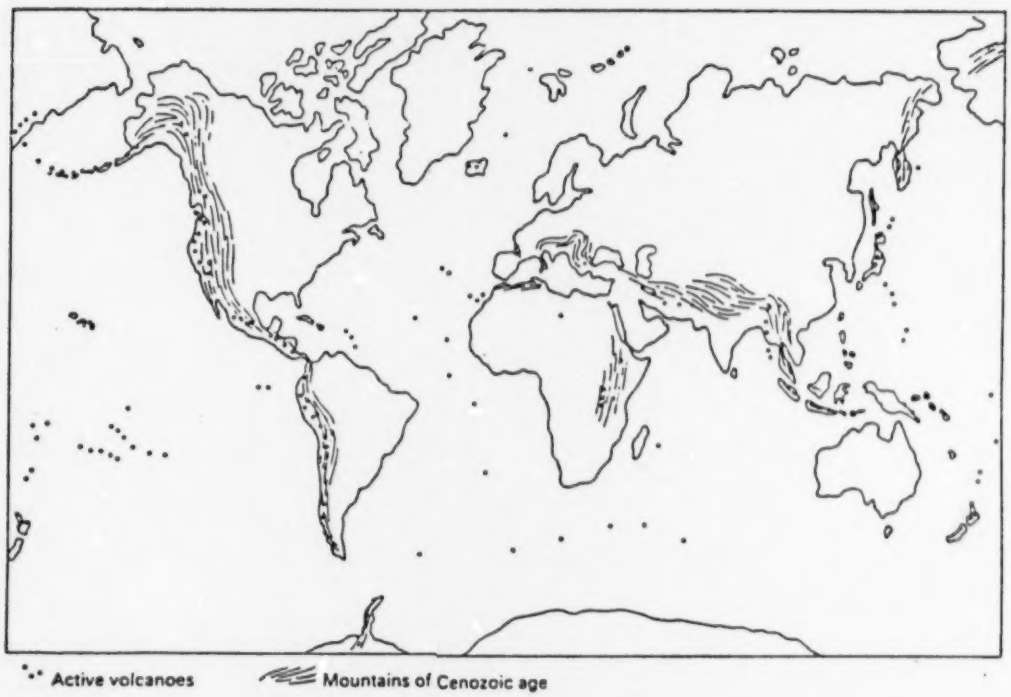

FIGURE 3 - World Distribution of Active Volcanoes
Source: Gilluly, Waters & Woodford, 1975, Principles of Geology, 4th Ed., W. H. Freeman & Co., San Francisco.

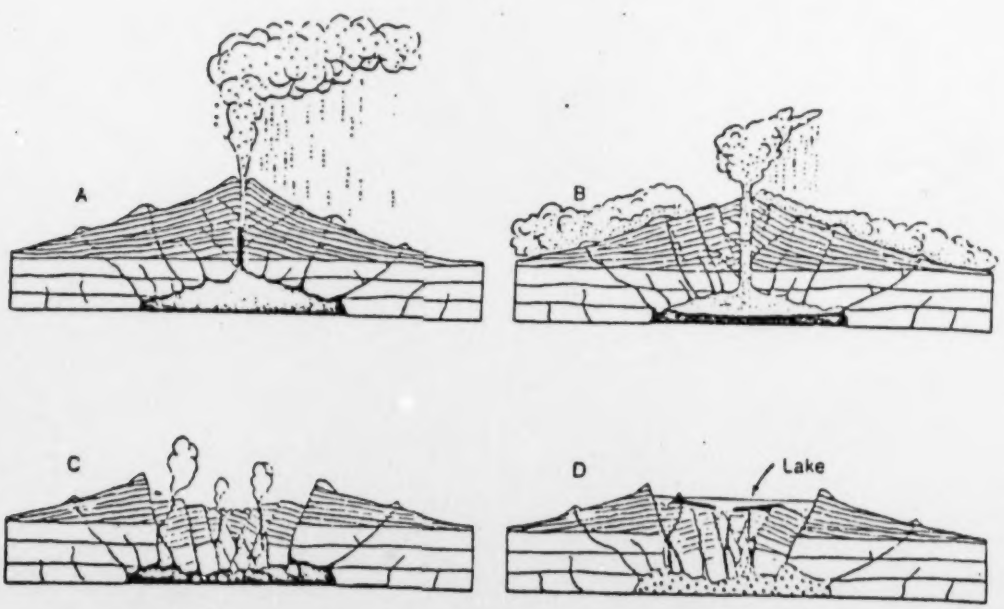

FIGURE 4. - Evolution of a volcanic cauldera
Source: as in Figure 3.

b. Canada and New Brunswick

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The end product of weathering (before transportation) is soil (Fig. 5, p. 17) which, under undisturbed conditions and long periods of time, would reflect the climate and original rock that have interacted to produce it. However, in N.B. we have a further complication in relatively recent geological time (10,000-20,000 years ago). Residual soil is that which remains in place, above the rock from which it was derived, for 1000's of years. In much of Canada, including to some extent N.B., glaciers, acting like giant bulldozers, have scoured and pushed off this earlier residual soil to new locations and left in its place, when the glacier melted, smoothly polished rock covered with some of the debris that was carried in the ice. This debris deposited by the ice is transported soil and covers much of N.B. (Fig. 6, p. 17).

The influence of glaciation on the distribution and type of soils in Canada is treated in Reference 4 (Douglas, 1970, Geology and Economic Minerals of Canada). Of particular interest

is the Glacial Map of Canada which illustrates the glacial features of this country as a whole (the instructor will display this map).

Weathering is a complex chemical and physical surface process the details of which need not be fully understood at this stage. However, the prospector should realize that in his/her search for ore in N.B., soils, mostly of the transported type, will be encountered on the surface over which he/she works to a far greater extent than rock outcrop. Indeed, many areas of N.B. are entirely covered by soil or glacial till and thus the prospector in this region is well advised to learn something about this material.

The types and distribution of soils in N.B. are also described and depicted in various maps and reports of the Department of Agriculture.

Several studies of glacial deposits in N.B. have been carried out by the Geological Survey of Canada and these results are contained within reports (with maps) available from the Department of Natural Resources (Mineral Resources Branch), Fredericton, (The instructor will display one of these glacial deposit maps). Studies of 'granular resources' for potential use by the construction industry, are being conducted by the Mineral Resources Branch of the provincial Department of Natural Resources and reports of this type will be useful for the prospector who takes the time and effort to learn how to use sources of information related to, but not necessarily specifically designed for, prospecting in the traditional sense.

RESIDUAL SOIL

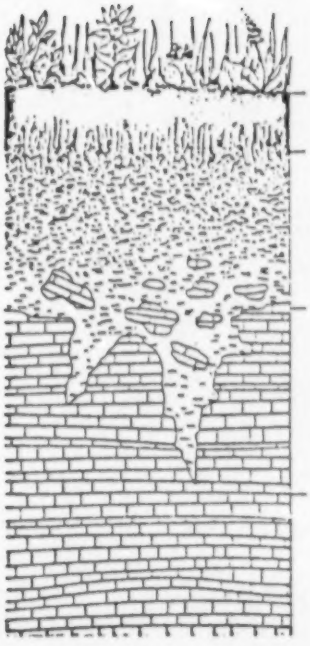

FIGURE 5. Generalized Residual Soil Profile

Source: Leet, Judson & Kaufman, 1978, Physical Geology, 5th Ed., Prentice Hall, Inc., N.J.

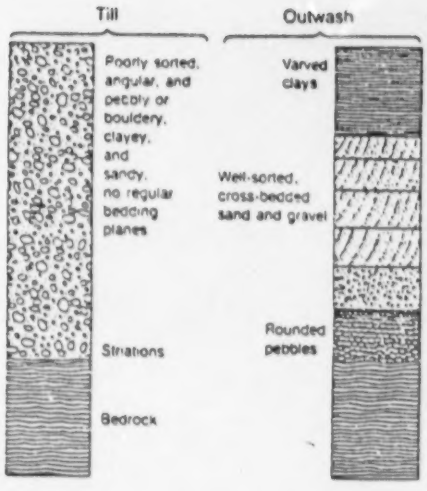

FIGURE 6. Transported Soils

Source: Press & Siever, 1978, W.H. Freeman & Co., San Francisco.

c. Weathering and Ores

Weathering produces chemical and physical changes in all rocks and the process can result in a natural concentration of ore minerals or elements sufficient to yield an ore from a rock in which the ore minerals/elements were originally too widely distributed.

In some cases the valuable mineral constituents withstand the weathering action much better than the less valuable minerals with which they may be associated. This may result in a separation wherein the valuable material remains in place and the less valuable substances are removed (transported) elsewhere. Such natural concentrations are called residual deposits. In other cases, the differing response of minerals to weathering and transportation processes may result in a sorting, away from the original site, to produce placer deposits.

Further examples of ores produced by surface processes are described in Reference 9 (Peters, 1978, Exploration and Mining Geology, p. 85).

In New Brunswick, glaciers have generally removed or redistributed the geologically old soils and surficial deposits in which ores might have been concentrated. However, some exceptions are known. Preferential concentration of silver minerals over the Heath Steele ore body near Newcastle appears to have been in earlier soils and sands produced by weathering of the ore deposit. Natural concentration by wave action close to Taylor's Island, near St. John, results in some low grade gold being present there.

In general the recent geological history of New Brunswick,

particularly in terms of the glacial redistribution of old soils. results in a much lower favourability for ore deposits produced by deep, prolonged weathering such as has occurred in areas that have experienced tropical climates for a comparable period of time.

3.3.4 The Water Cycle and Groundwater

a. General Information

Inseparable from a discussion of weathering is a consideration of the hydrologic cycle and groundwater. Indeed, weathering depends on surface and underground water which, in turn, depend on climate, topography and the characteristics of the crustal rocks.

The hydrologic cycle is diagramatically depicted in Figure 7, p. 20. It shows, in a generalized fashion, the cycle of surface water. The proportions of water in the several segments of the cycle will obviously differ from place to place on the earth's surface.

The cycle is typical of natural phenomena and is not difficult to understand. What is more difficult to appreciate is the effect that this cycle has, in its continuous operation, on the land surface. Some idea of this effect can be had from observing what happens to soil near a stream during a heavy rainstorm. The washing away of the unconsolidated material down slope into the stream and on to the ocean on the scale of one storm has to be multiplied by 1000's of such storms repeated over 1000's of years to gain an impression of the significance of the water cycle in modifying the earth's surface. This impression

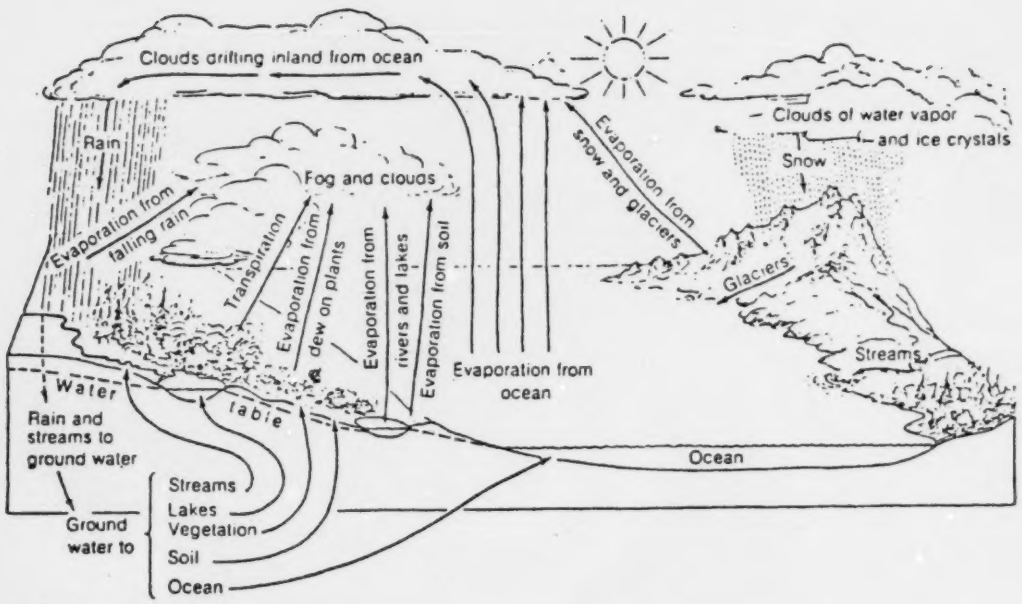

FIGURE 7.
The hydrologic cycle. [After *Principles of Geology* (4th ed.) by J. Gilluly, A. C. Waters, and A. O. Woodford. W. H. Freeman and Company. Copyright © 1975.]

FIGURE 7. - The Hydrologic Cycle

can also be obtained from observing the colour of streams and rivers emptying into bays and harbours during the annual spring freshet.

Less obvious than the action of surface water or runoff is that of the water which sinks below the surface. Groundwater does its important work of dissolving rocks and transporting mineral components to the sea much more slowly and less conspicuously. Its influence in shaping the land surface is nevertheless very significant.

Groundwater, as an 'agent', does most of its direct work of slowly altering rocks and thus changing the land surface in a chemical sense by dissolving and carrying in solution constituents of previously solid, crustal materials. However, it also serves to modify the landscape by lubricating both consolidated and unconsolidated material and thus making it more susceptible to the influence of gravity. This role of underground water is exemplified in land slides and slips that occur in mountainous regions and along rivers where the channel has cut under the banks.

As has been noted, different rocks respond to surface processes at different rates depending on a variety of factors among which are the characteristics of the rocks themselves. A good example of this is limestone and gypsum both of which are easily dissolved by groundwater. The tendency for rocks of this type to be modified by groundwater is so widespread and characteristic that a special name for the resulting topography has been adopted, "Karst". This type of topography is characterized by solution cavities, sink holes and other features

that result from the easy circulation in and solution of these rocks by groundwater. Examples of these topographic features occur in Albert Co., N.B.

The water cycle and underground water are discussed in Reference 6 (Holmes, 1978, Principles of Physical Geology, p. 26 and p. 261) and in Reference 10 (Plummer and McGeary, 1979, Physical Geology, Chapter 11, p. 193). An exercise on groundwater is presented in Chapter 11, p. 90 of the lab manuals. The aerial photographs and topographic maps of areas affected by groundwater action are worthy of examination. The problems may be worked on in the trainee's own time.

b. New Brunswick

Some area of Southeastern N.B. are underlain by soluble rocks that have been partly dissolved by surface and underground water. These areas, chiefly in Albert County, exhibit sink holes resulting from the solution of gypsum. This soluble rock is not uniformly widespread but rather interlayered with other deformed rocks so that Karst features are not continuous enough to produce a regional topography.

Ore deposits that form or are enriched in the surface environment and described in Reference 9 (Peters, 1978, Chapter 3, p. 85). In their formation groundwater generally plays an important role. Reference has already been made to the enriched zone above the Heath Steele deposits, west of Newcastle, N.B. In general, however, the local climate since the glacial period and the redistribution of most of the earlier soils during glaciation reduced the time available for the formation of surficial ore

deposits here.

3.3.5 Erosion of Weathered Material

a. General Information

The preceeding sections have referred in a general way to the breakdown of rocks at or near the surface. The slow solution and underground transportation of relatively small but significant amounts and kinds of material by groundwater has also been noted.

Weathering, both in its chemical and physical forms, converts previously hard, solid rock into softer, unconsolidated soil which is much more vulnerable to the forces operating continuously on the surface of the earth. These forces combine to shape and reshape the forms (topography) that constitute our landscape. They tend to reduce all land masses above sea level and build up through deposition those areas of the earth's surface that are below sea level. These processes have continued since the earth had a solid crust and atmosphere and they will continue. As has been noted, the rate of change may be slow when measured in time intervals with which we are familiar.

b. Gravity (Mass) Movements

Among the forces operating continuously on the earth's surface is gravity. In simplified terms this may be expressed as that force that tends to draw everything towards the centre of the earth. When rocks are softened and broken up by weathering and thus lose their cohesion, gravity is sufficient to bring them down to a lower position or closer to the earth's centre.

Surface modification by the process of gravity movements is more common and conspicuous in areas of steep slopes and sudden heavy rainfalls such as in tropical mountain regions where slides, slips, slumps occur frequently and in some cases, without warning. Movements of this type are less dramatic in the climate and topography of N.B. but they do occur on a small scale here, along the banks of rivers, sea shores, and road cuts.

Mass movements of surface material do not by themselves directly produce ore deposits. Their main interest for the prospector is in the fact that they may expose previously hidden indications of, or actual, mineralization.

"Mass wasting" is described in Reference 10, p. 151, and in Reference 6, p. 307.

c. Streams, Rivers and Lakes

By far the most widespread and continuous agent of erosion on the earth's surface are the rivers that carve land masses into valleys. This process continues until the land areas are reduced to sea level. Lakes are merely temporary (geologically) interruptions in the downward and sideward progress of rivers in degrading all areas of the earth's surface that are above sea-level. Transportation of weathered material by streams and rivers provides most of the sediment carried to the world's oceans. This transportation is effected by both mechanical and chemical means and ends ultimately with the variety of materials known as 'sediments' which, by compaction and cementation, become sedimentary rocks.

The movie seen in the previous session, "Rocks that form on

the Surface" depicts some of the action of streams and rivers in forming sedimentary rocks.

The literature on the action of rivers is extensive. Among the references recommended for this program, No. 10, Chapter 10, p. 167, provides a summary of the important features of these surface agents. Reference 6, Chapters 17, 18 and 19, presents more detailed information on rivers, their role in changing the landscape and the deposits derived from them. Chapter 9, in your lab manuals, deals with the subject of the changes in landscape as a result of continued erosion by many streams.

One of the features characteristic of the action of major rivers elsewhere in the world is the formation of deltas, large areas of thick river deposits slightly above or close to sea level that extend outward from the mouths of such rivers on the Mississippi, Nile, etc. The absence of such features at the mouths of N.B. rivers will be considered in the section of this session dealing with coastal currents, tides and waves.

New Brunswick possesses good examples of stream action ranging in scale from small brooks to our large rivers, like the St. John, Kennebacasis, Miramichi and many others. These and earlier rivers have reduced the mountains that characterized this region in the past. A measure of the work of our rivers can be had from the knowledge that our harbours have to be dredged of the sediment carried into them each year by major rivers. The results of local floods will also serve as an indication of the force of, and work done by, streams and rivers here.

Rivers in N.B. have been used by prospectors primarily as

a means of access throughout the province. The rivers represent ideal traverse routes since outcrop of bedrock is relatively abundant along them and new and/or larger outcrops appear after each freshet. N.B. Rivers have had their channels altered by glaciers in relatively recent geological time and thus surficial ore deposits that might have existed or been forming in them prior to glaciation have been dispersed from their original sites. It is unlikely that new river placer deposits have formed in the time since the last retreat of the ice sheet.

Elsewhere in the world now alluvial, placer ores of gold, platinum, diamonds, tungsten, iron, phosphate, titanium, iron are being worked from river deposits similar to those that formed in N.B. at various periods of our geological history. Thus, while recent placer deposits in N.B. are likely to have been disturbed or destroyed by the glaciers, the possibility of ancient or fossilized placer occurrences still exist where the appropriate sediments from ancient rivers have been preserved as rock in the geological column.

(An examination of the topographic map of southern N.B. will reveal some interesting features about our largest river. These topographic characteristics can be related to the geological features shown on the glacial map and the geological (bedrock map of the same area)).

d. Glaciation

As with many geological phenomena and processes, understanding these in a local area and restricted time span is not difficult where and when they are 'active'. What is

difficult is extending the 'action' beyond our customary scales of observation. Such is the case with glaciers. Whereas it is possible to observe the action of alpine glaciers in high mountain areas in many parts of the world, it is much more difficult to accept the evidence that some 20,000 years ago 2/3's of North America was covered by a thick layer of moving ice, much as we find today in Antarctica and Greenland.

Canadian history and, indeed, many aspects of current life here have been markedly influenced by our glacial past. The shape and course of our major rivers, on which early exploration depended, have been, in large part, determined by glacial action. Our thousands of fresh water lakes in the Canadian Shield (the largest supply in the world) are situated in basins scoured out of rock by the glacial 'sheets' or represent earlier rivers now dammed by glacial deposits that were 'dumped' when the glacial sheets retreated when the climate became warmer. Our cheap hydro-electric power sources, our rich prairie agricultural lands, our largely barren Canadian Shield are all the results of continental glaciation. Of particular interest to prospectors is the fact that our rapid discovery of mineral wealth in the 'Shield' is due, in no small measure, to the glaciers that removed most of the soil from that vast area and left bare, fresh, rock exposed to the eye and pick of the prospector.

So important has been glaciation to the economic life of Canada that this country has become one of the most thoroughly studied in this context of any in the world. The Glacial Map of Canada (a copy of which will be shown by the instructor) will indicate the extent and complexity of glacial activity in

Canada. More detailed studies are also available for most parts of the Country including N.B.

More information on this important agent of erosion is contained in Reference 10 (Chapter 12, p. 211) and in Reference 6 (Chapters 19 and 20, p. 360). Of special interest to Canadians is the information on continental glaciation.

Your lab manuals provide diagrams, aerial photographs and portions of maps of alpine glacial features (Chapter 14, p. 118) and continental glacial features in Canada and adjacent, similarly affected parts of the U.S. (Chapter 15, p. 126). Since the Maritime region was marginal to one of the main ice sheets, the features illustrated for the U.S. areas are similar to what are found here.

A series of slides on continental glaciation are provided in this session.

In New Brunswick continental glaciation has been no less important than elsewhere in Canada. Our major river valleys have been deepened, widened, made U-shaped and in the case of the St. John River blocked by glacial debris and diverted from its original course. N.B. was close to the ice margin during the several advances and retreats of the ice sheets. As a result, we find here evidence of glacial erosion produced during advances of the ice: glacial striae, the deepened and widened river valleys, and the rounded, polished, 'streamlined' rock outcrops. Evidence of continental glacial deposition is widespread in the form of eskers, erratics, moraines, drumlins. Glacial till is widespread in N.B. and much of what we refer to as 'soil', 'overburden' or 'drift', covering the surface here, was deposited by the glacial

sheet during its last retreat. Many of these features are depicted and described in various reports available from the Dept. of Natural Resources, Mineral Resources Branch (Gadd, N.R., 1973, Quarternary Geology of Southwest New Brunswick with Particular Reference to Fredericton Area, Paper 71-34, Geological Survey of Canada). It should also be appreciated that as the glacial ice retreated its melt waters formed large lakes over much of N.B. Deposits from these lakes are common surface features in many parts of the province.

As noted already, glacial features are of prime importance to N.B. prospectors for two reasons: 1) Glacial deposits cover much of the N.B. surface and thus 'mask' rock in which ore mineralization might otherwise be observed directly. This accounts, in part, for the later discovery of major ore deposits here as compared with parts of the Canadian Shield in Ontario and Quebec where bedrock discoveries in the 1920's and 1930's formed the basis of Canada's modern mineral industry. 2) One significant Pb-Zn-Cu occurrence on the Tetagouche River in northern N.B. was located in the late 30's by the simple technique of tracing mineralized boulders, scattered over the drift-covered surface by the glacier, back to their source area. Advances in prospecting techniques for glacial drift-covered areas have been made in Scandanavia and Canada. The N.B. prospector will do well to learn something about glacial processes here and he would also be wise not to 'write off' all areas covered by glacial drift.

Some glacial materials are being used in N.B. and elsewhere by the construction industry for roads, concrete, earth

filled dams, etc. Deposits appropriate for this purpose have certain strict specifications and the prospector might wish to keep these in mind during his traverses over drift-covered areas.

Glacial action does not directly contribute to the formation of metallic ore deposits. Its importance is in its ability to 'bull-doze clean' some outcrops that may contain visible mineralization which would otherwise have been covered. It is also important as an agent of mechanical dispersion that may spread ore mineralization 'downstream' from its source.

e. Coastal Currents, Tides and Waves

The turbulent waters of the Bay of Fundy shoreline provide excellent examples of the action by currents, tides and waves on the land masses adjacent to them. The more protected shorelines of Northumberland Strait and Chaleur Bay are markedly different in their topographic features due to differences in the rock types present but also due to the less turbulent water along those coasts.

Although the action of coastal waters may be intense, it is restricted to a narrow strip parallel to the shoreline. Rivers tend to reduce land masses to sea-level by their combined downward and sideways erosion and transportation of the derived material to the ocean depressions below sea level. In an analogous manner, coastal currents, tides and waves tend to erode and deposit, to a large extent, laterally along the shoreline destroying headlands or points and off-shore islands and depositing the derived material in bays, mouths of rivers, harbours, etc. The action of waves is restricted to fairly

shallow depths of about 100 feet below the surface of the water, thus, this most impressive of the coastal agents of erosion exercises its influence close to the shoreline except where the sea bottom is shallow for long distances from shore as for example along Northumberland Strait. Currents and tides are more subtle in their action and, in general, all of these agents act along rather than directly against the shoreline. Where the action of the along-shore waters is intense, as indicated by strong currents, high tides and large waves, deltas, characteristic of the mouths of large rivers emptying into the sea, cannot survive. The deposits that would otherwise produce a delta extending from the river mouth into the sea are moved along the shore and redeposited in the quieter waters of bays and inlets contributing still further to the straightening out of the shoreline. (For a map illustrating the Mississippi River Delta, see p. 113 of your lab manuals).

A discussion of coastal processes and forms (topography) will be found in Reference 6 (Holmes, 1978), Chapter 23, p. 497. For a treatment of deep ocean topography and deposition beyond the coastal zone, the reader is referred to the same source, Chapter 24, p. 538. If the trainee is interested in the broader, more scientific and hypothetical aspects of the origin of oceans and continents, Reference 6 (Chapters 25 and 29 inclus.) is recommended.

A more simplified and concise review of coastal features is available from Reference 10 (Plummer and McGeary, 1979), Chapter 14, p. 249.

The lab manuals provide a good series of topographic maps

of American coastline that illustrate the processes involved in their formation. Although these examples illustrated and described are American, the processes that formed them are in operation on a world-wide basis and equivalent features for most can be found in Canada and some in N.B.

The best known surface ore deposits found in coastal regions of the world are the beach placers of gold, platinum, chromite, titanium, rare earth elements, diamonds and iron. Deposits of this type are likely to have been disturbed and/or removed by the glacial sheet where they existed. However, the occurrence of gold in beach sands near Taylor's Island, west of St. John has been noted. Others may exist in areas 'sheltered' from glacial action. Others may have been formed in the geological past and been preserved by burial in the older deformed rocks. As with river and glacial deposits, construction and industrial materials (such as pure silica sand) are sorted, concentrated, and purified by beach processes and the prospector should be 'on the watch' for possibilities of this type particularly near urban centres.

Near-shore environments, close to sea-level (in both the lateral and vertical sense), where drainage is poor due to low stream gradients, are known to be appropriate for the accumulation of peat. Peat is widespread now in environments of this type in N.B. and it has accumulated under similar conditions in the past to be later buried to form coal and subsequently uplifted. Weather conditions appear to have been different during the earlier formation of coal.

Under different climatic conditions than those of recent

geological time here, near sea-shore environments appear to have been the sites in which evaporite deposits of salt, potash, gypsum and other relatively pure chemical compounds have precipitated from sea water 'locked into' restricted basins from which the water readily evaporated during periods of prolonged arid (desert) climate.

f. Wind

Wind continually operates as an erosional agent but its effectiveness alone in reducing solid rock to finer debris is much less significant than that of the other erosional agents previously referred to here. Wind containing dust, sand, and volcanic ash is an agent of erosion to be reckoned with in desert areas where this material can be readily picked up due to the lack of vegetation and water that elsewhere hold these materials together.

Since desert conditions do not exist in N.B. and wind as an erosional agent is comparatively insignificant here, its treatment will be brief. Interested readers may refer to References 6 (Chapter 22, p. 469), and 10 (Chapter 13, p. 234). Changes in topography resulting from erosion in arid regions are described and illustrated in the lab manuals (Chapter 10, p. 84).

D. SUMMARY

Surface geological processes result in distinctive forms (landscapes) and products (sediments) from which the recent geological history of an area can be interpreted with reasonable confidence. (The foregoing statement expresses one of the

fundamental principles in the geological sciences that of the Doctrine of Uniformitarianism which, simply stated, maintains that 'the present is the key to the past'.) In general the evidence, i.e. the forms and products, become less distinctive with time back into the geological past and correspondingly the confidence in interpretation is progressively reduced.

The study of the forms and their origins is that of geomorphology and those who wish to follow this subject in more detail will find a classical treatment in Lobeck, 1939, "Geomorphology", McGraw-Hill, New York, N.Y. For a more modern treatment of this interesting subject the reader is referred to Twidale, 1976, "Analysis of Landforms", John Wiley & Sons, New York, N.Y.

The study of the products or deposits of the surface geological processes is now a separate subdivision of the geological sciences known as, sedimentology. This discipline has itself become specialized (as a result of the extensive information acquired by its researchers) and the topic we have been chiefly concerned with in this session has been that of "Recent Sediments", or, more accurately, the processes by which they are formed. Furthermore, we have confined our brief review to those recent sediments that occur on or immediately adjacent to the continents. We have omitted from our study the subject of recent sediments in the so-called off-shore areas, a subject of increasing importance in mineral exploration.

It is fully appreciated by the author of these notes and the instructor that the trainee in this short program cannot hope

to understand or appreciate fully the information available on the various topics noted here. However, elementary coverage from the recommended references of these topics has been indicated and those interested can follow up on these and other sources.

The tabular summary that follows may help in organizing your thinking about surface processes.

	EROSION		TRANSPORTATION	DEPOSITION	
	Method of Erosion	Features of Erosion	Method	Cause of Deposition	Nature of Deposits
Mass Movement	slump sliding rolling dislodgement falling	slide scars surface subsidence	slump sliding rolling falling plastic flow creep	decrease in slope obstruction to movement loss of water	talus cones talus sheets rock glaciers mud flows felsenmeer
Running Water	corrosion hydraulicking	river valleys pediments peneplains river terraces wadies (in deserts) pot holes	suspension solution saltation (bouncing) rolling pushing & dragging	decrease in velocity decrease in slope decrease in volume change in channel barriers to flow	alluvial fans bars channel fill alluvial terraces deltas levees flood plain deposits
Wind	deflation corrosion abrasion impact	undercut hills cave rocks table, mushroom rocks ventifacts desert pavement log gravels	saltation suspension rolling	loss of velocity settling of heavy particles rain	loess volcanic ash & dust dunes (Barchan, longitudinal, transverse, seif, parabolic
Glaciation	quarrying (plucking) abrasion	striations & grooves drumlins polished surfaces crescentic marks U-shaped valleys truncated spurs hanging valleys cirques fiords cofs aretes horns	suspension dragging carrying on top pushing	melting of ice breaking up of ice in ocean	moraines (lateral, terminal, recessional, medial, ground) eskers kames kame terraces outwash varved lake clays erratics
Ground Water	solution	caves sinkholes karst topography	in solution (same as surface running water)	precipitation due to 1) evaporation 2) loss of acidity 3) chemical reactions loss of velocity	spring terraces stalactites & stalagmites cementation of sediments (pore filling) vein & cavity filling

FIG. 8 TABULAR SUMMARY OF SURFACE DEPOSITS

	EROSION		TRANSPORTATION	DEPOSITION	
	Method of Erosion	Features of Erosion	Method	Cause of Deposition	Nature of Deposits
Mass Movement	slump sliding rolling dislodgement falling	slide scars surface subsidence	slump sliding rolling falling plastic flow creep	decrease in slope obstruction to movement loss of water	talus cones talus sheets rock glaciers mud flows felsenmeer
Running Water	corrosion hydraulicking	river valleys pediments peneplains river terraces wadies (in deserts) pot holes	suspension solution saltation (bouncing) rolling pushing & dragging	decrease in velocity decrease in slope decrease in volume change in channel barriers to flow	alluvial fans bars channel fill alluvial terraces deltas levees flood plain deposits
Wind	deflation corrosion abrasion impact	undercut hills cave rocks table, mushroom rocks ventifacts desert pavement log gravels	saltation suspension rolling	loss of velocity settling of heavy particles rain	loess volcanic ash & dust dunes (Barchan, longitudinal, transverse, seif, parabolic
Glaciation	quarrying (plucking) abrasion	striations & grooves drumlins polished surfaces crescentic marks U-shaped valleys truncated spurs hanging valleys cirques fiords cofs aretes horns	suspension dragging carrying on top pushing	melting of ice breaking up of ice in ocean	moraines (lateral, terminal, recessional, medial, ground) eskers kames kame terraces outwash varved lake clays erratics
Ground Water	solution	caves sinkholes karst topography	in solution (same as surface running water)	precipitation due to 1) evaporation 2) loss of acidity 3) chemical reactions loss of velocity	spring terraces stalactites & stalagmites cementation of sediments (pore filling) vein & cavity filling